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LARVAL CESTODE PARASITES OF EDIBLE MOLLUSKS OF THE NORTHEASTERN GULF OF MEXICO

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ABSTRACT Ten distinct species of larval cestodes were obtained from 43 edible, or potentially edible, benthic mollusks of the northeastern Gulf of Mexico. Three of the infected mollusks, American oysters, *Crassostrea virginica* (Gmelin), Atlantic bay scallops, *Argopecten irradians concentricus* (Say), and sunray venus clams, *Macrocallista nimbosa* (Lightfoot), are important commercial species in the eastern Gulf and the remainder are occasionally eaten by epicurean shellfishermen or were consumed by prehistoric, aboriginal Indians of the Gulf coast. The cestodes represent four orders, seven families and nine recognized genera and include the trypanorhynchs, *Eutetrarhynchus* sp. (of Cake 1975) and *Parachristianella* sp. (of Cake 1975), the lecanicephalideans, *Polypocephalus* sp. (of Cake 1975) and *Tylocephalum* sp. (of Burton 1963), the tetraphyllideans, *Dioecotaenia cancellata* (Linton 1890), *Anthobothrium* sp. (of Cake 1975), *Rhinebothrium* sp. (of Cake 1975), *Acanthobothrium* sp. (of Regan 1963), and *Acanthobothrium* sp. (of Harry 1969), and the diphyllidean, *Echinobothrium* sp. (of Cake 1975). Infected mollusks were widely distributed in coastal estuarine and marine habitats from the Mississippi Sound to the Florida Keys. Pelecypods appear to serve as primary intermediate hosts and molluscivorous gastropods appear to serve as secondary intermediate or paratenic (transport) hosts for these cestodes which in turn utilize demersal elasmobranch fish as final hosts. None of these cestodes are known to infect humans and the only potential harm is to the quality and quantity of the edible molluscan tissues.

INTRODUCTION

This report was derived from a three-year study of larval cestode parasites of shallow-water, benthic mollusks of the eastern Gulf of Mexico. During that study 2,470 mollusks, representing 36 gastropod species, 55 pelecypod species, and one octopod, were collected from 30 localities between Bay St. Louis, Mississippi, and the Dry Tortugas archipelago of Florida and examined for larval cestodes. A list of hosts and parasites and a provisional key to the molluscan cestodes of the eastern Gulf of Mexico has been published elsewhere (Cake 1976). For the sake of brevity, the literature pertaining to molluscan cestodes of the Gulf is presented in synoptic form in Table 1.

The infection data reported and analyzed herein were derived from those mollusks which are harvested by commercial and sport shellfishermen, from those occasionally consumed by epicurean shellfishermen, from those which were consumed by aboriginal Indians of the northern Gulf coast, and from congeners of edible mollusks. These four categories are based on present edibility standards, on the suggestions of the late epicurean, Euell Gibbons (1964), and a senior Gulf coast zoologist, Gordon Gunter (1971), and on archaeological data from Willey (1949) and Percy (1973). Gibbons considered almost any marine or estuarine mollusk edible but his choices in the Gulf were restricted to 10 gastropods and 12 pelecypods. Gunter reported that 15 gastropods and 21 pelecypods from the Gulf were edible or potentially edible. Willey and Percy reported shell remains of 17 gastropods and 14 pelecypods from aboriginal Indian garbage mounds (or kitchen middens) along the northern Gulf coast of Florida.

Only one case of human infection by a related cestode is known. Heinz (1954) reported that a five-year-old Ecuadorian boy spontaneously passed a *Hepatoxylon* sp. larva (Trypanorhyncha) while in a bathtub. The author hypothesized that the larva came from an improperly cooked marine fish of that area which is commonly infected. This should not be considered a true infection since the larva did not establish itself in the boy's body.

The cestode nomenclature follows that of Schmidt (1970) with the exception of *Anthobothrium* Beneden, which he splits, and *Rhinebothrium* Linton, which he does not recognize. The molluscan nomenclature follows that of Abbott (1974).

MATERIALS AND METHODS

Benthic mollusks were collected at 30 Gulf coast localities between Bay St. Louis, Mississippi, and Dry Tortugas, Florida, from shallow, subtidal, grass, mud and sand flats and coral and oyster reef habitats via skin and scuba diving, wading, hand and shovel digging, etc. Based on preliminary studies (Cake 1972), large pelecypods (i.e., clams, oysters, pen shells, scallops) and molluscivorous gastropods (i.e., conchs, tulip snails, whelks) were collected and transported alive in 190-liter styrofoam containers to several coastal marine laboratories for dissection and examination. The following tissues and organs were examined for cestode larvae: in pelecypods—the gills, labial palps, stomach and stomach walls, intestine and intestine walls, intestinal pouches (if present), digestive gland and diverticula, gonads, and foot musculature; in gastropods—the valve of Leiblein (if enlarged), esophagus and esophageal pouches (if present),

TABLE 1.

Synoptic review of larval cestode parasites reported from mollusks of the Gulf of Mexico.

Larval Cestode Species	Molluscan Hosts	Tissue Location	Geographic Locality	Reference	Remarks
TRYPANORHYNCHA					
Parachristianella sp. (as *P. dimegacantha* Kruse)	*Argopecten irradians concentricus* (Say) *Macrocallista nimbosa* (Lightfoot) *Spisula solidissima similis* (Say)	Encysted singly along walls of intestine of all hosts; and in foot musculature of *M. nimbosa* and *S. s. similis*	St. Teresa Beach, Florida	Cake 1972	Encysted
Nybelinia sp. (as "*Scolex*" sp. VIII)	*Donax variabilis* Say *Atrina seminuda* (Lamarck)	Digestive gland	Galveston Beach, Texas	Wardle 1974	
LECANICEPHALIDEA					
Polypocephalus sp.	*A. i. concentricus*	Digestive gland	St. Teresa Beach, Florida	Cake 1972	Encysted singly in small groups in clear-walled sacs
Tylocephalum sp.	*Crassostrea virginica* (Gmelin)	Gills, palps, gut epithelium	Apalachicola Bay, Florida	Burton 1963	Encysted
Tylocephalum sp.	*C. virginica*	Connective and Leydig tissues	Choctawhatchee and Tampa Bays, Florida	Quick 1971	Encysted
Tylocephalum sp. (of Burton 1963)	*A. i. concentricus* *M. nimbosa* *S. s. similis*	Digestive tract walls, and digestive gland of all hosts; foot of *M. nimbosa* and *S. s. similis*	St. Teresa Beach, Florida	Cake 1972	Encysted
TETRAPHYLLIDEA					
Acanthobothrium sp. (as "*Scolex pleuronectis*" Müeller)	*Melongena corona* Gmelin	Mantle cavity	Live Oak Island, Apalachee Bay, Florida	Regan 1963	Free in cavity
Acanthobothrium sp. (of Regan 1963)	*Fasciolaria tulipa* Linné	Digestive tract	Mullet Key, Tampa Bay, Florida	Friedl and Simon 1970	Free in gut
Acanthobothrium sp. (of Regan 1963)	*F. tulipa* *Fasciolaria lilium hunteria* (Perry) *Pleuroploca gigantea* (Kiener) *M. corona* *Polinices duplicatus* (Say)	Digestive tract	Alligator Harbor (Region), Franklin County, Florida	Hamilton and Byram 1974	Free in gut
Acanthobothrium sp. (of Regan 1963)	*P. gigantea* *Thais haemastoma* (Linné)	Digestive tract	Galveston Beach, Texas and off-shore platforms in area	Wardle 1974	Free in gut
Acanthobothrium sp. (as "*Scolex pleuronectis*" Müeller)	*Raeta* (= *Anatina*) *plicatella* Lamarck	Gutwall cysts or sacs	Galveston Bay, Texas	Harry 1969	Plerocercoids share cysts or sacs
Acanthobothrium sp. (of Harry 1969)	*Tagelus plebeius* (Solander) *Macoma constricta* (Bruguière)	Stomach and intestines	Galveston Bay, Texas	Wardle 1974	Free in gut
Dioecotaenia cancellata (Linton)	*Anadara ovalis* (Bruguière)	Stomach and intestines	Galveston Beach, Texas	Wardle 1974	Free in gut
Anthobothrium sp. (as *Rhodobothrium* sp.)	*M. nimbosa*	Visceral mass/mantle cavity	St. Teresa Beach, Florida	Cake 1972	Claviform sac containing worm hangs in mantle cavity
Anthobothrium sp. (of Cake 1972)	*D. variabilis*	Visceral mass/mantle cavity	Galveston Beach, Texas	Wardle 1974	Claviform sac containing worm hangs in mantle cavity

TABLE 1 (Continued).

Synoptic review of larval cestode parasites reported from mollusks of the Gulf of Mexico.

Larval Cestode Species	Molluscan Hosts	Tissue Location	Geographic Locality	Reference	Remarks
TETRAPHYLLIDEA (Continued)					
Rhinebothrium sp. (as *Echeneibothrium* sp.)	*A. i. concentricus* *M. nimbosa* *S. s. similis*	Stomach and digestive diverticula	St. Teresa Beach, Florida	Cake 1972	Free in gut, confined in diverticula
Rhinebothrium sp. (of Cake 1972)	*A. seminuda* *Crepidula fornicata* (Linnē) *C. plana* Say *Dosinia discus* Reeve *Noetia ponderosa* (Say) *Periploma inequale* (C. B. Adams) *R. plicatella*	Stomach and intestine	Galveston Beach, Texas	Wardle 1974	Free in gut, confined in diverticula

stomach and stomach walls, digestive gland and diverticula.

All examinations were made with the aid of a stereoscopic, dissecting microscope. The larvae were removed or excised (if encysted), identified (usually to family or species type), counted and either fixed and preserved or placed in petri dishes of filtered seawater (at 30‰ salinity and ambient temperature) for further observations. Selected larvae of *Acanthobothrium* spp., *Rhinebothrium* sp., and *Polypocephalus* sp. were incubated for up to 150 hours in a glucose-enriched, artificial elasmobranch saline medium (*vide:* Read et al. 1960; Hamilton and Byram 1974) to facilitate identification. During incubation some larval features (e.g., apical suckers and bothridial precursors) were lost or modified (e.g., quadriloculate bothridia became triloculate with terminal suckers or pads on *Acanthobothrium* spp. larvae), and some rudimentary adult features developed (e.g., bothridial hooks on larvae of *Acanthobothrium* spp.).

The larvae were killed in an expanded or relaxed condition with tepid tap water or hot (ca 50°C) alcohol-formalin-acetic acid (AFA), fixed in AFA, and preserved in 70% ethanol with 5% glycerine. Large post-plerocercoids of *Anthobothrium* sp. were killed in an expanded condition (bothridia attached to petri dish bottom) with liquid nitrogen and fixed and preserved as above. The larvae were stained with either Van Cleave's combination hematoxylin or Erlich's acid hematoxylin and mounted on slides via standard helminthological techniques.

RESULTS

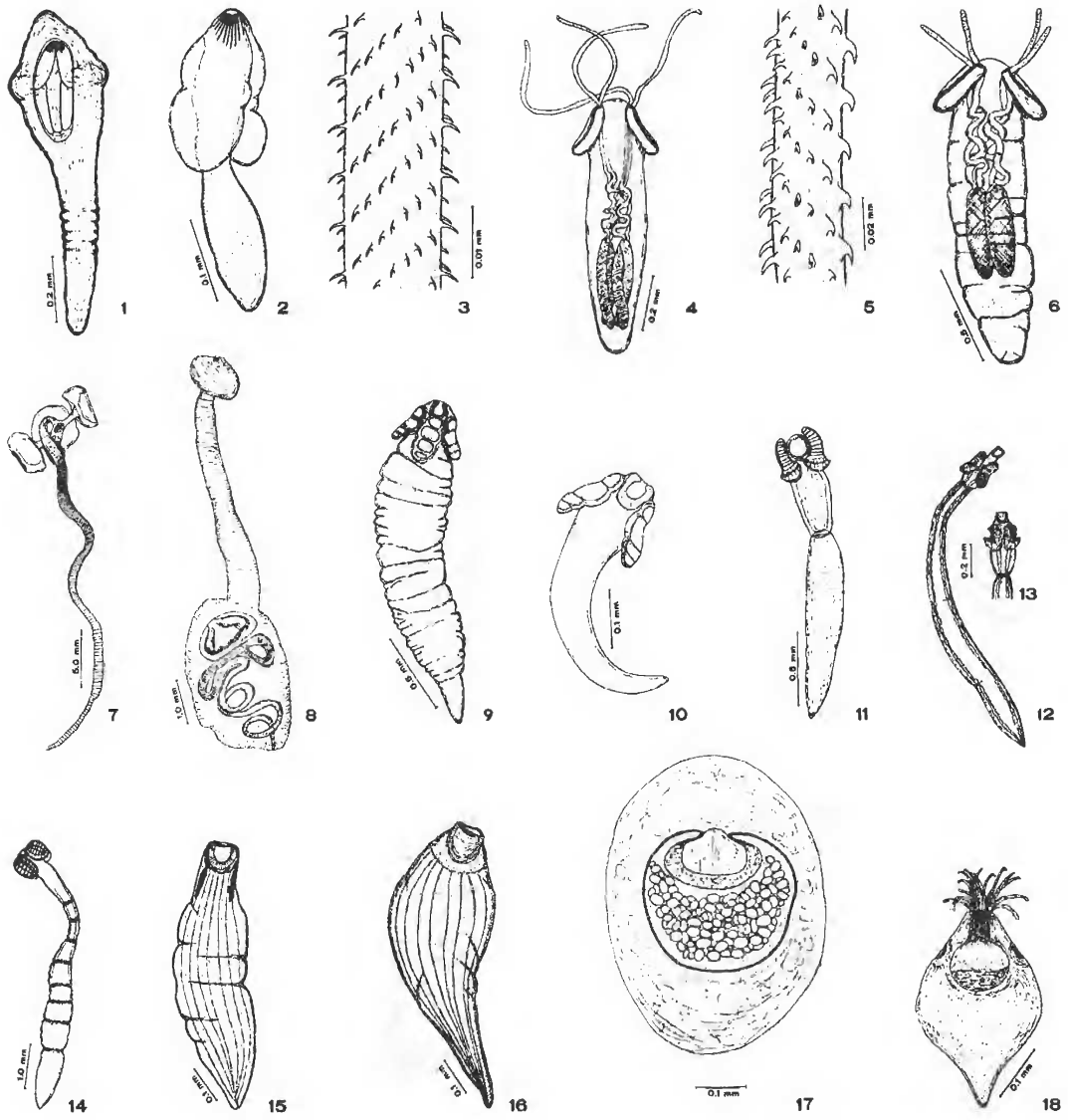
Ten distinct species of larval cestodes were recovered from 43 edible or potentially edible, benthic mollusks of the eastern Gulf of Mexico. The cestodes represent four orders, seven families and nine recognized genera as follows:

Order: Trypanorhyncha
Family: Eutetrarhynchidae
Genus: *Eutetrarhynchus* sp. (of Cake 1975)
Parachristianella sp. (of Cake 1975)
Order: Lecanicephalidea
Family: Lecanicephalidae
Genus: *Polypocephalus* sp. (of Cake 1975)
Family: Cephalobothriidae
Genus: *Tylocephalum* sp. (of Burton 1963)
Order: Tetraphyllidea
Family: Dioecotaeniidae
Genus: *Dioecotaenia cancellata* (Linton 1890)
Family: Phyllobothriidae
Genus: *Anthobothrium* sp. (of Cake 1975)
Rhinebothrium sp. (of Cake 1975)
Family: Onchobothriidae
Genus: *Acanthobothrium* sp. (of Regan 1963)
Acanthobothrium sp. (of Harry 1969)
Order: Diphyllidea
Family: Echinobothriidae
Genus: *Echinobothrium* sp. (of Cake 1975)

Those ten species and two unidentified tetraphyllidean larval forms are illustrated in Figures 1–18. The unidentified forms (Figures 15 and 16) are probably early plerocercoids of *Acanthobothrium* sp. (of Regan 1963) (Figure 9) and *Rhinebothrium* sp. (of Cake 1975) (Figures 11, 12, and 13), respectively. The early plerocercoids of each species concurrently infect the same molluscan host as the advanced, identifiable plerocercoids and in some instances a complete developmental sequence of plerocercoids is present in a single host.

A complete list of molluscan hosts for these cestodes was published previously (Cake 1976, Table 1). The edible molluscan hosts of each cestode are listed along with appropriate bibliographic data on their actual or potential edibility in Table 2.

Seven species of edible pelecypods (by present standards) were infected by one or more larval cestode species. Three of those pelecypods—bay scallops, *Argopecten irradians*



Figures 1–18. Larval cestodes of Gulf of Mexico mollusca (after Cake 1976). 1. Longicaudate, invaginated acanthorostellobothridiocysticercoid of *Echinobothrium* sp. (of Cake) from *Nassarius vibex*. (Cut-away view showing invaginated scolex.) 2. Scolex of *Echinobothrium* sp. (of Cake) from *N. vibex*. 3. Metabasal armature of internal tentacle surface of *Eutetrarhynchus* sp. (of Cake) tentaculoneoplerocercoid from *Pleuroploca gigantea*. 4. Tentaculo-neoplerocercoid of *Eutetrarhynchus* sp. (of Cake) from *P. gigantea*. 5. Side view of metabasal armature of tentacle of *Parachristianella* sp. (of Cake) tentaculo-neoplerocercoid from *Macrocallista nimbosa*. 6. Tentaculoneoplerocercoid of *Parachristianella* sp. (of Cake) from *M. nimbosa*. 7. Bothridio-postplerocercoid of *Anthobothrium* sp. (of Cake) from *Anadara transversa*. 8. Claviform capsule containing bothridio-postplerocercoid of *Anthobothrium* sp. (of Cake) from *A. transversa*. (Cut-away view showing coiled postplerocercoid.) 9. Bothridio-plerocercoid of *Acanthobothrium* sp. (of Regan) from *Oliva sayana*. 10. Bothridio-plerocercoid of *Acanthobothrium* sp. (of Harry) from *Ensis minor*. 11. Bothridio-plerocercoid of *Rhinebothrium* sp. (of Cake) from *Argopecten irradians concentricus*. 12. Bothridio-plerocercoid of *Rhinebothrium* sp. (of Cake) from *Busycon spiratum pyruloides*. 13. Contracted scolex (bothridia) of *Rhinebothrium* sp. from *B. s. pyruloides*. 14. Bothridio-plerocercoid of *Dioecotaenia cancellata* (Linton 1890) from *Chione cancellata*. 15. Uniacetabulo-plerocercoid of *Acanthobothrium* sp. (of Regan) from *Fasciolaria tulipa*. 16. Uniacetabulo-plerocercoid of *Rhinebothrium* sp. (of Cake) from *C. cancellata*. 17. Encysted, acaudate glando-procercoid of *Tylocephalum* sp. (of Burton) from *Argopecten irradians concentricus*. 18. Tentaculo-plerocercoid of *Polypocephalus* sp. (of Cake) from *A. i. concentricus*.

TABLE 2.

Summary of larval cestode parasites of edible or potentially edible benthic mollusks of the eastern Gulf of Mexico.

Edible Mollusks Found to be Infected During the Present Study	Larval Cestode Species											References to Edible Mollusks
	Acanthobothrium (Regan)	*Acanthobothrium* (Harry)	*Anthobothrium* sp.	*Dioecotaenia cancellata*	*Rhinebothrium* sp.	Unknown Tetraphyllidean*	*Echinobothrium* sp.	*Eutetrarhynchus* sp.	*Parachristianella* sp.	*Polypocephalus* sp.	*Tylocephalum* sp. (Burton)	1. Gibbons 1964 2. Gunter 1971 3. Percy 1973 4. Willey 1949 5. Present Study
GASTROPODS:												
Busycon contrarium (Conrad) (as *B. preversum*-2)					X						X	1, 2, 3, 4
Busycon spiratum pyruloides (Say)	X				X	X		X	X		X	1, 2, 3
Cantharus cancellarius (Conrad)	X				X	X	X		X		X	2
Crepidula spp.					X	X		X	X		X	1, 2, 4
Fasciolaria lilium hunteria (Perry) (as *F. distans*-3)	X				X	X		X	X		X	2, 3
Fasciolaria tulipa (Linné) (as *Fasciolaria* sp.-3)	X				X	X		X	X		X	3, 4
Melongena corona Gmelin	X			X	X	X		X			X	2, 3, 4
Murex fulvescens Sowerby											X	2, 3, 4
Murex sp. [probably *M. pomum* (Gmelin)]	X										X	3
Oliva sayana Ravenel	X				X						X	2, 3, 4
Pleuroploca gigantea (Kiener) (as *Fasciolaria g.*-3)	X				X			X			X	2, 3
Polinices duplicatus (Say)	X	X			X				X		X	1, 2, 3, 4
Thais haemastoma canaliculata (Gray) (as *Thais* sp.-1)								X			X	1, 2
PELECYPODS:												
Arca sp.											X	3
Argopecten irradians concentricus (Say) (as *Pecten* sp.-3, 4)		X	X		X	X		X	X	X	X	2, 3, 4
Atrina rigida (Lightfoot)					X			X	X		X	1
Atrina seminuda (Lamarck)								X	X		X	2
Chama macrophylla (Gmelin)											X	3
Chione (spp.-1) *cancellata* (Linné)				X	X	X			X		X	1, 2, 3, 4
Crassostrea virginica (Gmelin) (as *Ostrea v.*-3, 4)											X	1, 2, 3, 4
Crytopleura costata (Linné)						X					X	1
Dinocardium robustum (Lightfoot) (as *Cardium* sp.-3)											X	1, 2, 3
Donax variabilis (Say)					X				X		X	1, 2, 3
Dosinia discus (Reeve)					X	X			X		X	2, 3
Dosinia elegans Conrad					X						X	5
Ensis spp.		X			X	X		X			X	1
Laevicardium sp.											X	1
Macrocallista maculata (Linné)									X		X	5
Macrocallista nimbosa (Lightfoot)			X						X		X	2
Mercenaria campechiensis (Gmelin) (as *Venus* sp.-3)											X	1, 2, 3
Mercenaria m. texana (Dall) (as *Venus m.*-3, 4)											X	1, 2, 3, 4
Modiolus m. squamosus Beauperthuy						X					X	5
Noetia ponderosa (Say)	X				X	X			X		X	2, 3
Periglypta listeri (Gray)											X	5
Pinctada imbricata Röding											X	5
Pinna carnea Gmelin											X	1
Pseudochama radians (Lamarck)											X	5
Pseudomiltha floridana (Conrad) (as *Lucina f.*)		X										2
Pteria colymbus (Röding)											X	5
Spisula solidissima similis (Say)			X		X				X		X	1, 2, 3
Spondylus americanus Hermann											X	5
Tagelus plebeius (Solander)		X			X							2
Tagelus spp.		X			X							1
Trachycardium egmontianum (Shuttleworth)					X						X	1

*Uniacetabulo-plerocercoids of *Acanthobothrium* sp. (Regan) and/or *Rhinebothrium* sp. (Cake)

concentricus (Say); American oysters, *Crassostrea virginica* (Gmelin); and sunray venus clams, *Macrocallista nimbosa* (Lightfoot)—are harvested commercially in the northeastern Gulf. Four additional species—the southern and Texas quahog clams, *Mercenaria campechiensis* (Gmelin) and *M. mercenaria texana* (Dall); the surf clam, *Spisula solidissima similis* (Say); and the coquina or beach clam, *Donax variabilis* (Say)—are frequently collected and consumed by sport shellfishermen, skin and scuba divers and beachcombers. Large quantities of oysters are consumed raw (alive on the half shell), while the remaining species are baked, broiled, chowdered, fried, steamed, etc., prior to consumption. Occasionally coquina clams are eaten raw by epicurean beachcombers.

Eight species of cestodes were recovered from these seven edible pelecypods and their infection data are summarized in Table 3. One should note that the larvae of *Tylocephalum* sp. and *Parachristianella* sp. were the most prevalent in that group. *Tylocephalum* larvae occurred in all seven pelecypods. Bay scallops were infected by the largest number of species, seven, while oysters contained only one species.

The seven pelecypods cited above do not constitute the only edible mollusks that harbor larval cestodes. According to Euell Gibbons (1964), mollusks of 14 additional (infected) genera and/or species that occur in the Gulf are edible. These include the fulgur whelks, *Busycon contrarium* (Conrad) and *B. spiratum* [subpsecies *pyruloides* (Say)]; the slipper shells, *Crepidula* spp., the Atlantic moon snail, *Polinices duplicatus* (Say); the rock shells, *Thais* spp.; the pen shells, *Atrina* spp. and *Pinna carnea* Gmelin; the venus clams, *Chione* spp.; angel wing clams, *Cytopleura costata* (Linné); the cockles *Dinocardium robustum* (Lightfoot), *Trachycardium egmontianum* (Shuttleworth), and *Laevicardium* spp.; the jackknife clams, *Ensis* spp.; the mussels, *Modiolus* spp.; and the tagelus clams, *Tagelus* spp. Gunter (1971) listed eight additional (infected) edible or potentially edible Gulf mollusks including the cancellate cantharus, *Cantharus cancellarius* (Conrad); the banded tulip snail, *Fasciolaria lilium hunteria* (Perry) (as *F. hunteria*); the giant eastern murex, *Murex fulvescens* Sowerby; the lettered olive, *Oliva sayana* Ravenel; the half-naked pen shell, *Atrina seminuda* (Lamarck); the disk clam, *Dosinia discus* (Reeve); the Florida lucine, *Pseudomiltha floridana* (Conrad) (as *Lucina f.*); the ponderous ark, *Noetia ponderosa* (Say); and the stout tagelus clam, *Tagelus plebeius* (Lightfoot). The larval cestode parasites of these edible mollusks are presented in Table 2.

Seven additional potentially edible (and infected) pelecypods are included in Table 2 because of their abundance and fleshy appearance or because they are congeners of edible species. Notable among this group are the princess venus clam, *Periglypta listeri* (Gray), the calico clam, *Macrocallista maculata* (Linné), and the Atlantic thorny oyster, *Spondylus americanus* Hermann.

Prehistoric aboriginal inhabitants of the eastern Gulf coast harvested and consumed numerous species of molluscan

TABLE 3.

Larval cestode infection data from seven edible Pelecypods of the eastern Gulf of Mexico.

Infected Mollusk Species	Larval Cestode Species: (No. Infected Mollusks/No. Larvae/No. Stations)								Total Number of Mollusks/ Stations
	Acanthobothrium (Harry)	*Anthobothrium* sp.	*Rhinebothrium* sp.	Unidentified Tetraphyllidean*	*Eutetrarhynchus* sp.	*Parachristianella* sp.	*Polypocephalus* sp.	*Tylocephalum* sp. (Burton)	
Argopecten irradians concentricus (Say)	1/1/1	1/1/1	67/1,460/8	1/3/1	2/3/1	42/222/3	42/777/4	68/5,639/8	78/11
Crassostrea virginica (Gmelin)								60/950/13	138/20
Donax variabilis Say			23/35/2			5/6/1		1/1/1	120/3
Macrocallista nimbosa (Lightfoot)		1/1/1				60/1,674/7		39/462/7	69/9
Mercenaria campechiensis (Gmelin)								6/101/5	26/10
Mercenaria mercenaria texana (Dall)								3/477/2	4/2
Spisula solidissima similis (Say)		1/1/1	23/77/2			30/520/2		8/42/1	35/3

*Probably unfacetabulo-plerocercoids of *Rhinebothrium* sp.

shellfish that are now known to harbor larval cestodes. Archaeological data from kitchen middens or garbage mounds at 32 coastal sites west of the Aucilla River in the Florida panhandle indicate that coastal Indians consumed and/or utilized the shells of at least 18 species of marine gastropods and 15 species of marine pelecypods (Willey 1949; Percy 1973). In some middens 95% of the faunal remains consisted of mollusk shells. Larval cestodes presently infect nine of those gastropods and eleven of those pelecypods (Table 2).

Only five potentially edible mollusks listed by Gibbons (1964) and Gunter (1971) appear to be devoid of larval cestodes. This may be misleading because of the small sample size (ten or fewer specimens were examined). These include the Atlantic ribbed mussel, *Geukensia demissa granosissima* (Sowerby) (syn. *Modiolus demissus granosissimus*); the hooked mussel, *Ischadium recurvum* (Rafinesque) (syn. *Brachidontes recurvus*); the tulip mussel, *Modiolus americanus* (Leach); and the frons oyster, *Lopha frons* (Linné) (syn. *Ostrea frons*).

All of the cestodes found in edible or potentially edible mollusks of the eastern Gulf utilize elasmobranch fish (sharks, skates or rays) as final hosts and probably will not develop in humans that consume viable larvae. The majority of the cestodes were confined to the mollusk's visceral region and those tissues are usually separated from the edible portion, during processing, and discarded. Those cestodes that remain in the edible portion, or in mollusks that are prepared whole, are destroyed by the cooking process. The *Tylocephalum* larvae that are ingested by humans who consume raw (living) oysters, coquina clams or other infected pelecypods, are not known to be infective. Experimental evidence obtained during this study suggests that those larvae are destroyed by human digestive acids and enzymes. While attempting to remove individual *Tylocephalum* larvae from small pieces of oyster tissue via digestion (*in vitro*), I found that a 1% solution of hydrochloric acid and pepsin in seawater would kill all encysted larvae in a short period of time.

Larvae of *Tylocephalum* sp. (Burton 1963) were the most abundant, widely distributed, and least host-specific of all cestodes that infected edible mollusks. They occurred in all but three of the 43 infected mollusks covered in this report. They were found in mollusks from every type of estuarine and marine habitat sampled and were distributed from the Mississippi Sound to the Florida Keys. Plerocercoids of *Rhinebothrium* sp. (Cake 1975) were the next most abundant larval forms; they occurred in 24 of 43 infected mollusks from every type of marine habitat between the Mississippi Sound and the Florida Keys. Three other cestodes, *Parachristianella* sp. (Cake 1975) (15 of 43), *Eutetrarhynchus* sp. (Cake 1975) (11 of 43), and *Acanthobothrium* sp. (Regan 1963) (10 of 43) were common parasites of edible mollusks, but were restricted to fewer habitats, smaller geographic ranges, and occurred in smaller numbers of infected hosts. The remaining cestode species exhibited more host-specificity, but were restricted to fewer habitats and smaller geographical ranges. The larvae of *Polypocephalus* sp. (Cake 1975) occurred only in bay scallops, *A. i. concentricus*, and only in shallow bays adjacent to the Apalachicola River in northwest Florida.

DISCUSSION

The most important consequence of larval cestode infections in edible mollusks is the effect that those infections, especially heavy infections, have on the health of the host. Heavy infections certainly cause physiological stress which may affect growth, reproduction, and edibility. Heavy infections of *Parachristianella* sp. in sunray venus clams, *M. nimbosa*, severely restrict the passage of food material through the host's intestine. Sparks (1963) suggested that heavy *Tylocephalum* infections in oysters, *C. virginica*, at West Loch, Pearl Harbor, Hawaii, were responsible for the low condition index, a measure of fatness or marketability, that he observed. [Condition Index = Dry meat weight (gm) X 100/Shell volume (ml).] Wolfe (1976) noted the presence of heavy *Tylocephalum* infections in Sidney rock oysters, *Saccostrea* (syn. *Crassostrea*) *commercialis* Iredale and Roughley, from northern Australia. He suggested that the physiological stress caused by the infections produced the "poor, transparent, and watery" conditions noted in all infected oysters.

Pelecypods appear to serve as primary intermediate hosts while molluscivorous gastropods appear to serve as secondary intermediate or paratenic (transport) hosts for these larval cestodes. Most of the molluscan hosts are confirmed prey of demersal elasmobranchs of the Gulf of Mexico. Pelecypods and filterfeeding, herbivorous and omnivorous gastropods (e.g., *Crepidula* spp.) become infected by ingesting reproductive products (e.g., eggs and gravid proglottids released by the definitive hosts) or free-swimming coracidia. Molluscivorous gastropods become infected by ingesting infected pelecypods or gastropods. The first infection mode is based on circumstantial feeding and infection information (Cheng 1966), and the second mode was demonstrated during this investigation. Cheng found coracidia of *Tylocephalum* sp. in the digestive tract and intimately associated with the gills of *Tylocephalum*-infected oysters, *C. virginica*. Banded tulips, *F. l. hunteria*, infrequent hosts of *Rhinebothrium* sp. (Cake 1975), exhibited statistically significant increases in total numbers of larvae when fed *Rhinebothrium*-infected ponderous arks, *N. ponderosa* (unreported data).

Only one larval cestode, *Dioecotaenia cancellata* (Linton), could be identified to species, while the remainder were identified only to a generic level because they lacked definitive, adult characteristics. Four larval species, *Acanthobothrium* sp. (of Regan), *Acanthobothrium* sp. (of Harry) *Rhinebothrium* sp. (of Cake), and *Polypocephalus* sp. (of

Cake), were identified as a result of incubation experiments using an artificial elasmobranch saline solution (Read et al. 1960; Hamilton and Byram 1974). Considerable research, including improved infection and incubation experiments, needs to be conducted before these larval forms can be identified completely or described as new species.

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